WHAT WE CLAIM IS:

1. A high hard, strength and tough nano-crystal metal bulk material, comprising an aggregate of metal nano-crystal grains, wherein a metal oxide or a semimetal oxide exists as a crystal grain growth inhibitor between and/or in said nano-crystal grains.

2. A high hard, strength and tough nano-crystal metal bulk material, comprising an aggregate of metal nano-crystal grains, wherein a metal nitride or a semimetal nitride exists as a crystal grain growth inhibitor between and/or in said nano-crystal grains.

3. A high hard, strength and tough nano-crystal metal bulk material, comprising an aggregate of metal nano-crystal grains, wherein a metal carbide or a semimetal carbide exists as a crystal grain growth inhibitor between and/or in said nano-crystal grains.

4. A high hard, strength and tough nano-crystal metal bulk material, comprising an aggregate of metal nano-crystal grains, wherein a metal silicide or a semimetal silicide exists as a crystal grain growth inhibitor between and/or in said nano-crystal grains.

5. A high hard, strength and tough nano-crystal metal bulk material, comprising an aggregate of metal nano-crystal grains, wherein a metal boride or a semimetal boride exists as a crystal grain growth inhibitor between and/or in said nano-crystal grains.

6. A high hard, strength and tough nano-crystal metal bulk material, comprising an aggregate of metal

nano-crystal grains, wherein:

at least two compounds selected from the group consisting of (1) a metal oxide or a semimetal oxide, (2) a metal nitride or a semimetal nitride, (3) a metal carbide or a semimetal carbide, (4) a metal silicide or a semimetal silicide and (5) a metal boride or a semimetal boride exist as a crystal grain grown inhibitor between and/or in said nano-crystal particles.

7. The high hard, strength and tough nano-crystal metal bulk material according to any one of claim 1 to 6, wherein the bulk material comprising an aggregate of metal nano-crystal grains contains nitrogen in an amount of 0.01 to 5.0% by mass.

8. The high hard, strength and tough nano-crystal metal bulk material according to any one of claims 1 to 6, wherein the bulk material comprising an aggregate of metal nano-crystal grains contains nitrogen in an amount of 0.1 to 2.0% by mass.

9. The high hard, strength and tough nano-crystal metal bulk material according to any one of claims 1 to 8, wherein the bulk material comprising an aggregate of metal nano-crystal grains contains a metal oxide form of oxygen in an amount of 0.01 to 1.0% by mass.

10. The high hard, strength and tough nano-crystal metal bulk material according to any one of claims 1 to 9, which further comprises a metal element having a stronger chemical affinity for nitrogen than a nano-crystal metal so as to prevent denitrification of the aggregate

comprising metal nano-crystal grains in a forming-by-sintering process.

11. The high hard, strength and tough nano-crystal metal bulk material according to any one of claims 1 to 10, wherein a nano-crystal metal-forming component is at least one element selected from the group consisting of aluminum, magnesium, zinc, titanium, calcium, beryllium, antimony, yttrium, scandium, indium, uranium, gold, silver, chromium, zirconium, tin, tungsten, tantalum, iron, nickel, cobalt, copper, niobium, platinum, vanadium, manganese, molybdenum, lanthanum, rhodium, carbon, silicon, boron, nitrogen and phosphor.

12. The high hard, strength and tough nano-crystal metal bulk material according to any one of claims 1 to 10, wherein a nano-crystal metal-forming component is a dental platinum-group element.

13. The high hard, strength and tough nano-crystal metal bulk material according to any one of claims 1 to 10, wherein a nano-crystal material is one or two or more intermetallic compounds selected from the group consisting of Ni_3Al, Fe_3Al, FeAl, Ti_3Al, TiAl, $TiAl_3$, $ZrAl_3$, $NbAl_3$, NiAl, Nb_3Al, Nb_2Al, $MoSi_2$, Nb_5Si_3, Ti_5Si_3, Nb_2Be_{17}, Co_3Ti, $Ni_3(Si, Ti)$, SiC, Si_3N_4, AlN, TiNi, ZrB_2, HfB_2, Cr_3C_2, and Ni_3Al-Ni_3Nb.

14. The high hard, strength and tough nano-crystal metal bulk material according to any one of claims 1 to 13, wherein the metal nano-crystal grains have been obtained by mechanical milling (MM) or mechanical alloying (MA)

using a ball mill or the like.

15. A process for preparing a nano-crystal metal bulk material, which involves steps of:

applying mechanical alloying (MA) to respective fine powders of nano-crystal metal-forming components, using a ball mill or the like, thereby preparing fine powders of a nano-crystal metal, and

applying to said fine powders of a nano-crystal metal hot forming-by-sintering treatment such as sheath rolling, spark plasma sintering or extrusion, or explosive forming, thereby obtaining a high hard, strength and tough metal bulk material.

16. A process for preparing a nano-crystal metal bulk material, which involves steps of:

mixing respective fine powders of nano-crystal metal-forming components together with a substance that becomes a nitrogen source,

applying mechanical alloying (MA) to the resulting mixture, using a ball mill or the like, thereby preparing high nitrogen-concentration, nano-crystal metal powders, and

applying to said metal powders hot forming-by-sintering treatment such as sheath rolling, spark plasma sintering or extrusion, or explosive forming, thereby obtaining a high hard, strength and tough metal bulk material.

17. The process for preparing a nano-crystal metal bulk material according to claim 16, wherein the substance

that becomes a nitrogen source is a metal nitride.

18. The process for preparing a nano-crystal metal bulk material according to claim 16, wherein the substance that becomes a nitrogen source is N_2 gas or NH_3 gas.

19. The process for preparing a nano-crystal metal bulk material according to any one of claims 15 to 18, wherein an atmosphere in which mechanical milling or mechanical alloying is applied is any one gas selected from the group consisting of (1) an inert gas such as argon gas, (2) N_2 gas, and (3) NH_3 gas or (4) a mixed gas of two or more gases selected from (1) to (3).

20. The process for preparing a nano-crystal metal bulk material according to claim 19, wherein an atmosphere in which mechanical milling or mechanical alloying is applied is an atmosphere of a gas with some reducing substance such as H_2 gas added thereto.

21. The process for preparing a nano-crystal metal bulk material according to claim 15 or 16, wherein an atmosphere in which mechanical milling or mechanical alloying is applied is a vacuum, a vacuum atmosphere with some reducing substance such as H_2 gas added to a vacuum or a reducing atmosphere.

22. The process for preparing a nano-crystal metal bulk material according to any one of claims 16 to 21, which involves steps of:

mixing the respective fine powders of nano-crystal metal-forming components and 1 to 10% by volume of a metal nitride or 0.5 to 10% by mass of a nitrogen affinity metal

having a stronger chemical affinity for nitrogen than a nano-crystal metal together with a substance that becomes a nitrogen source,

applying mechanical alloying (MA) to the resulting mixture, using a ball mill or the like, thereby preparing high-nitrogen nano-crystal metal powders, and

applying to said metal powders hot forming-by-sintering treatment such as sheath rolling, spark plasma sintering or extrusion, or explosive forming, wherein said additive nitride is dispersed or a nitride, carbo-nitride or the like of said metal element is precipitated or dispersed in a mechanical alloying (AM) process or a forming-by-sintering process of mechanically alloyed (MA) powders, thereby obtaining a high hard, strength and tough metal bulk material.

23. The process for preparing a nano-crystal metal bulk material according to any one of claims 15 to 22, wherein a nano-crystal metal has a blending composition containing 0 to 40% by mass of other element, and the forming-by-sintering is carried out at a temperature that is at least 10% lower than a melting point or melting temperature of said nano-crystal metal.

24. A process for preparing a high hard, strength and tough nano-crystal steel bulk material, which involves steps of:

applying mechanical alloying (MA) to respective powders of nano-crystal steel-forming components using a

ball mill or the like, thereby preparing nano-crystal steel powders, and

applying to said steel powders forming-by-sintering treatment such as spark plasma sintering, hot pressing, extrusion or rolling, or explosive forming at or near a superplasticity-inducing temperature of said steel powders.

25. A process for preparing a high hard, strength and tough nano-crystal cast iron bulk material, which involves steps of:

applying mechanical alloying (MA) to respective powders of nano-crystal cast iron-forming components using a ball mill or the like, thereby preparing nano-crystal cast iron powders, and

applying to said cast iron powders forming-by-sintering treatment such as spark plasma sintering, hot pressing, extrusion or rolling, or explosive forming at or near a superplasticity-inducing temperature of said cast iron powders.

26. A process for preparing a high hard, strength and tough nano-crystal steel formed material, which involves steps of:

applying mechanical alloying (MA) to respective powders of nano-crystal steel-forming components using a ball mill or the like, thereby preparing nano-crystal steel powders,

applying to said steel powders forming-by-sintering treatment such as spark plasma sintering, hot pressing, extrusion or rolling, or explosive forming, thereby obtaining a steel bulk material, and

forming said steel bulk material at or near a super-plasticity-inducing temperature of said steel bulk material.

27. A process for preparing a high hard, strength and tough nano-crystal cast iron formed material, which involves involving steps of:

applying mechanical alloying (MA) to respective powders of nano-crystal cast iron-forming components using a ball mill or the like, thereby preparing nano-crystal cast iron powders,

applying to said cast iron powders forming-by-sintering treatment such as spark plasma sintering, hot pressing, extrusion or rolling, or explosive forming, thereby obtaining a cast iron bulk material, and

forming said cast iron bulk material at or near a super-plasticity-inducing temperature of said cast iron bulk material.